CURRENT LITERATURE

NOTES FOR STUDENTS

Metabolism of fungi.—Among recent papers on the metabolism of fungi two on protein synthesis are of special interest. The first by EHRLICH[1] relates to the utilization of the nitrogen of amino acids when substances other than sugar form the source of energy. In his former work EHRLICH showed that in the presence of sugar the α-amido acids are transformed by yeast into carbon dioxide, ammonia, and alcohols with one carbon atom fewer than the corresponding amino acids, the ammonia being used in protein synthesis, while the carbon residue is excreted as a waste product. In the present paper he reports the results of an investigation of the action of yeasts on an amino acid, tyrosin, when simpler compounds such as alcohol, glycerine, lactic acid, etc., are supplied as sources of carbon. He finds that the decomposition of the amino acid proceeds in the same manner regardless of the source of carbon, and that even with these less favorable sources of energy the nitrogenous radical only of the amino acid is utilized by the organism. In cultures containing cane sugar, glycerine, or alcohol in addition to tyrosin, small quantities of esters and volatile fatty acids were formed. *Oidium lactis* was found to behave in an analogous manner. EHRLICH and JACOBSON had shown that in the presence of sugar this fungus produces from amino acids the corresponding oxyacids. Its behavior in this respect was not changed when glycerine, lactic acid, or alcohol were used instead of sugar. With each of these substances tyrosin yielded paraoxyphenyl lactic acid, only the nitrogenous portion of the molecule being utilized by the fungus.

PURIEWITSCH[2] approached the problem of protein synthesis from another point of view, by determining the energy required, as measured by the carbon dioxide output per unit of dry weight of fungus, for the assimilation of different nitrogenous compounds by *Aspergillus niger*. Of the large number of nitrogenous compounds tested with sugar, low ratios of carbon dioxide to dry weight were obtained with methyl urea, the amino acids, potassium sulphocyanate, acetamide methyl amine, and urea, while such compounds as guanidin, ethylamine, potassium nitrate, peptone, protein, and phenyl urea gave higher ratios, showing that more energy is required for their assimilation. Fewer nitrogenous compounds were tried in connection with succinic acid, malic acid,

[1] EHRLICH, F., Über die Bildung des Plasmaeiweisses bei Hefen und Schimmelpilzen. Biochem. Zeitschr. 36:477–497. 1911.

[2] PURIEWITSCH, K., Untersuchungen über die Eiweisssynthese bei niederen Pflanzen. Biochem. Zeitschr. 38:1–13. 1912.

or tartaric acid in place of sugar. The ratios for these acids were higher than those obtained with sugar, and they increased for the different acids in the order in which the acids are named. The general arrangement of the nitrogenous compounds in the order of their assimilability was essentially the same for these acids as for sugar.

As a result of his experiments, PURIEWITSCH favors the view of CZAPEK, according to which the α-amino acids serve directly as materials for protein synthesis. He has overlooked, however, much of the recent work of EHRLICH and others who have shown conclusively, for yeasts and *Oidium lactis* at least, that it is only the amido group in the form of ammonia that is used for protein synthesis, while the rest of the molecule is entirely rejected. The author, therefore, is in error when he states that there is no evidence that the ammonia split off from organic compounds serves as a source of material for protein synthesis.

A further contribution to the subject of nitrogen metabolism of fungi has been made by EHRLICH and PISTSCHIMUKA,[3] in their study of the fermentation of the primary amines. They find that with yeasts, especially *Willia anomala* and wild yeasts, and *Oidium lactis*, these substances undergo a fermentation, resulting, like the analogous fermentation of amino acids, in the production of the higher alcohols. The process results in a substitution of the amido group by the hydroxy group according to the following general reaction:

$$R \cdot CH_2 \cdot NH_2 \xrightarrow[-NH_3]{+H_2O} R \cdot CH_2OH$$

By this process tyrosol was obtained from p-oxyphenylethylamine and fusil oil from isoamylamine. As in the case of the amino acids, only the nitrogenous part of the molecule is utilized by the organisms, the rest of the molecule being transformed into the corresponding alcohol.

The easy fermentation of amines to the corresponding alcohols raises the question whether the transformation of amino acids to alcohols does not take place with the intermediate formation of amines rather as NEUBAUER and FROMHERZ[4] believe, than with the intermediate formation of keto-acids.

In continuation of his studies on nitrogen metabolism, EHRLICH[5] reports a further example of the fermentation of an amino acid with the production of the corresponding alcohol. He obtained tryptophol (β-indolylethyl alcohol) by the action of yeast on trytophan (β-indolyl alanin). The chemical properties of the new compound are described in detail.

The influence of nutrition on the secretion of enzymes by fungi, a problem concerning which different investigators have arrived at different conclusions,

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[3] EHRLICH, F., und PISTSCHIMUKA, P., Überführung von Aminen in Alkohole durch Hefe- und Schimmelpilze. Ber. Deutsch. Chem. Gesells. **45**: 1006–1012. 1912.

[4] Rev. BOT. GAZ. **54**: 343. 1912.

[5] EHRLICH, F., Über Tryptophol (β-indolylethyl Alcohol) ein neues Gärprodukt der Hefe aus Aminosäuren. Ber. Deutsch. Chem. Gesells. **45**: 883–889. 1912.

has been investigated by GREZES[6] with respect to the production of invertase and other enzymes by *Aspergillus niger;* and by KNUDSON with respect to the production of tannase by *Aspergillus niger*, *Penicillium rugulosum*, and an unknown species of *Penicillium*.

GREZES finds that *Aspergillus niger*, even when grown on RAULIN'S solution containing no sugar and with succinic acid as the sole source of carbon, produces invertase, diastase, maltase, inulase, and emulsin. A quantitative study of the production of invertase by the fungus on media containing, on the one hand cane sugar and on the other succinic acid, a substance not related to the carbohydrate group, showed that the production of the enzyme is greatly influenced by the mode of nutrition. Only small quantities of invertase are produced by cultures on succinic acid, yet its production is not entirely suppressed, even after 60 spore-generations on succinic acid, and nearly normal production immediately takes place if the fungus is transferred to sugar solutions. The author concludes that the power of invertase production is an inseparable characteristic of the fungus.

KNUDSON[7] finds that tannase is not produced by *Aspergillus niger* nor by the species of *Penicillium* which he studied if there is no tannic acid or its decomposition product, gallic acid, in the solution. If either of these substances is present there is a progressive increase in the production of tannase with increase of concentration of the acids. With a constant concentration of tannic acid the production of the enzyme is depressed with increasing concentration of sugar. Mycelia grown on various organic compounds other than gallic acid contain no tannase. Gallic acid stimulates the production of tannase even in solutions containing 10 per cent of cane sugar.

A number of papers deal with the hydrolysis by fungi of glucosides, tannin, and other less complex compounds. UHLENHAUT[8] studied the hydrolysis of amygdalin by the action of fungi, but, aside from extending somewhat the list of fungi capable of splitting amygdalin, his paper adds nothing essential to that which is already known concerning the process. The 14 species which he investigated differed considerably, as judged by purely qualitative tests, in their capacity for hydrolyzing the glucoside. The mucors were in general found to be more active in this respect than the higher fungi. The growth of the mucors on amygdalin solutions was usually soon inhibited, owing to the accumulation of benzene cyanhydrin, to which the author ascribes the hydrocyanic acid odor developed in the cultures. If, however, other fungi capable of utilizing the excess of cyanhydrin are grown in cultures together with mucors,

[6] GREZES, G., Recherches sur la sucrase de l'*Aspergillus niger*. Ann. Inst. Pasteur **26**:556–573. 1912.

[7] KNUDSON, L., Tannic acid fermentation. II. Effect of nutrition on the production of the enzyme tannase. Jour. Biol. Chem. **14**:185–202. 1913.

[8] UHLENHAUT, H., Über die Spaltung des Amygdalins durch Schimmelpilze. Ann. Mycol. **9**:567–621. 1911.

the mucors flourish better than in pure cultures. With other sources of carbon present amygdalin is more or less protected from the action of fungi. The influence of other factors, such as light, metal salts, and osmotic pressure on the hydrolysis of amygdalin by fungi is also considered. Quantitative data are entirely absent from the paper.

In a short paper HÉRISSEY and LEBAS[9] report that aucubine, the glucoside of *Aucuba Japonica*, is hydrolyzed by *Aspergillus niger* in acid solution and more slowly in neutral solution. Fuller details as to the mode of hydrolysis are lacking.

KNUDSON[10] reports the results of a series of investigations on the hydrolysis of tannic acid by fungi. He finds that the substance is generally toxic in concentrations of 2–5 per cent. Of 23 species of fungi, representing mucors, ascomycetes, and basidiomycetes, only 3, *Aspergillus niger*, *A. flavus*, and a species of *Penicillium*, made good growth, on a 10 per cent solution. *Aspergillus niger* was originally described from material growing on tannic acid solution by VAN TIEGHEM, who first observed that this organism and a species of *Penicillium* ("*P. glaucum*") brought about the hydrolysis of tannin with the formation of gallic acid. KNUDSON studied the action of *Aspergillus niger* and a species of *Penicillium* probably different from that of VAN TIEGHEM, and finds that the *Aspergillus* is the more active in bringing about the hydrolysis of tannic acid. A part of the gallic acid formed is consumed by the fungi. The extent to which the acid is consumed depends on the presence of other more favorable food substances. In a synthetic culture solution containing tannic acid the gallic acid is consumed to a greater extent than in gall-nut infusions which contain other food substances. In a 10 per cent sugar solution the gallic acid is left intact. The hydrolysis takes place also under anaerobic conditions, and under both aerobic and anaerobic conditions a part of the enzyme diffuses into the culture medium.

Statements by PRINGSHEIM and ZEMPLÈN that certain fungi (*Rhizopus tonkinensis*, *Mucor javanicus*, *Penicillium purpurogenum*, *P. africanum*, and *P. brevicaule*) not possessing invertase are capable of utilizing cane sugar have led RITTER to reinvestigate the behavior of a number of fungi in relation to their capacity for utilizing that sugar. His results are in accord with the general proposition that in fungi, as well as in higher plants and in animals, cane sugar is not capable of direct assimilation, but can be utilized only by those organisms producing invertase. Among the fungi which RITTER[11] tested, *Mucor spinosus*, *M. javanicus*, *Thammidium elegans*, *Rhizopus nigricans*, and *R. tonkinensis*

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[9] HÉRISSEY, H., et LEBAS, C., Utilization de l'aucubine par l'*Aspergillus niger* v. Tgh. Compt. Rend. Soc. Biol. Paris **70**:846–848. 1911.

[10] KNUDSON, L., Tannic acid fermentation I. Jour. Biol. Chem. **24**:159–184. 1913.

[11] RITTER, G. E., Über das Verhältnis der Schimmelpilze zum Rohrzuoker. Biochem. Zeitschr. **42**:1–6. 1912.

made practically no growth on nutrient solutions containing cane sugar with potassium nitrate or ammonium tartrate as sources of nitrogen. *Penicillium purpurogenum*, which grew well on cane sugar, was found to contain invertase, contrary to the statement of PRINGSHEIM and ZEMPLÈN.

JEGOROFF,[12] studying the assimilability of phytin by mold fungi (*Aspergillus niger* and *Penicillium* sp.), confirms the results of DOX, according to which that substance is hydrolyzed by the action of molds, the phosphorous radicle being utilized as a source of phosphorus by the fungi. Sterilization of nutrient solutions containing phytin does not in itself cause hydrolysis of the substance. In cultures containing peptone and cane sugar inorganic phosphorus (potassium dihydrogen phosphate) gave a better yield than phytin, but in cultures containing only cane sugar or only glycerine as sources of carbon, phytin gave better yields than inorganic phosphorus. Peptone gave low yields with both phytin and potassium dihydrogen phosphate, the culture showing little difference in favor of either.

The work of a number of investigators has shown that urea, uric acid, hippuric acid, and glycocoll serve not only as sources of carbon and nitrogen for fungi, but also as sources of nitrogen for green plants. The availability of these compounds as nutrients for fungi has been further investigated by KOSSOWICZ[13] with reference to the following fungi: *Botrytis Bassiana*, *Penicillium crustaceum*, *P. brevicaule*, *Mucor Boidin*, *Cladosporium herbarum*, *Phytophthora infestans*, *Aspergillus glaucus*, *A. niger*, *Isaria farinosa*, and a species of *Fusisporium*. He finds that in cultures with cane sugar all the fungi made good growth in solutions containing urea or uric acid; *Cladosporium herbarum* failed to grow on solutions containing glycocoll; and *Penicillium crustaceum*, *P. brevicaule*, *Aspergillus glaucus*, and *Cladosporium herbarum* failed to grow on hippuric acid. In later experiments, however, in which dextrose or mannite were substituted for cane sugar, and the culture solution was somewhat modified as to its inorganic constituents, these four species also were able to utilize all of the compounds in question. The cause of this peculiar difference of behavior is not discussed. Some of these compounds served as sources of both carbon and nitrogen for certain of the fungi. Uric acid served thus for *Aspergillus glaucus*, *Isaria farinosa*, *Penicillium glaucum*, *Mucor Boidin*, *Phytophthora infestans*, and *Botrytis Bassiana;* hippuric acid for *P. glaucum*, *A. niger*, *A. glaucus*, *I. farinosa*, *B. Bassiana*, *Ph. infestans*, *Cladosporium herbarum*, and *Fusisporium;* and glycocoll for *P. glaucum*, *C. herbarum*, *B. Bassiana*, *I. farinosa*, *Ph. infestans*, *A. niger*, *A. glaucus*, and *M. Boidin*.

[12] JEGOROFF, M. A., Über das Verhalten von Schimmelpilzen (*Aspergillus niger* und *Penicillium crustaceum*) zum Phytin. Zeitschr. Physiol. Chem. **82**:231–242. 1912.

[13] KOSSOWICZ, A., Die Zersetzung von Harnstoff, Harnsäure, Hippursäure, und Glykokoll durch Schimmelpilze. Zeitschr. Gärungsphysiol. **1**:60–62. 1912; also **2**:51–54. 1912.

In connection with these experiments KOSSOWICZ[14] has examined the action of the extracts of six of the species of fungi on uric acid and on hippuric acid. He confirms the results of earlier investigators who have shown that the fermentation of hippuric acid is an enzymatic process, and shows also that the decomposition of uric acid by fungi is a process of similar nature. Extracts of *Aspergillus niger*, *Mucor Boidin*, *Phytophthora infestans*, *Isaria farinosa*, and *Botrytis Bassiana* were found to ferment both acids, while extracts of *Cladosporium herbarum* acted only on uric acid.

The acceptance of the liberation of ammonia as a criterion of the fermentation of hippuric acid has been criticized by DOX and NEIDIG,[15] who find as a result of quantitative determinations of the glycocoll produced in the process that ammonia is formed only in small quantities as a result of secondary decomposition of glycocoll.

The mode of absorption and utilization of fats by fungi has been investigated by SPIECKERMANN.[16] By means of cultures on infusorial earth, from which the residual acids could be extracted, he was able to show that the higher fatty acids in the form of their salts (soaps, especially the calcium and the ammonium soaps whose decomposition does not result in the accumulation of strong alkali in the cultures) are utilized to a large extent. The somewhat contrary results of SCHMIDT are to be ascribed to his use of alkali soaps whose decomposition caused too great a degree of alkalinity of the culture medium. In cultures on agar plates in which sodium nitrate was present and in which the free fatty acids were distributed in a finely divided state throughout the agar, a broad clear zone, indicating the formation of soap by the action of the alkali set free by the utilization of the nitrate group, appeared around the colonies. When ammonium sulphate was used instead of sodium nitrate a narrower zone appeared about the colonies, showing that even in the acid medium an extracellular solution of the fatty acids takes place, although the process here is not as readily explained as in the first case. Similar phenomena observed with reference to fats show that they also undergo extracellular solution before being absorbed by living cells. From these observations the author concludes that fats are taken into the cell in the form of soaps or as free fatty acids.

As a result of an examination of a large number of yeasts and other budding fungi, as well as a number of filamentous forms found in connection with the industries dependent on fermentation, LINDNER and CZISER[17] find that the

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[14] KOSSOWICZ, A., Die enzymatische Natur der Harnsäure- und Hippursäure-Gärung. Zeitschr. Gärungsphysiol. **1**:121–123. 1912; also **1**:317–319. 1912.

[15] DOX, A. W., and NEIDIG, R. E., Enzymatische Spaltung von Hippursäure durch Schimmelpilze. Zeitschr. Physiol. Chem. **85**:68–71. 1913.

[16] SPIECKERMANN, A., Die Zersetzung der Fette durch höhere Pilze. I. Der Abbau des Glycerins und die Aufnahme der Fette in die Pilzzelle. Zeitschr. Unters. Nahrungs- und Genussmittel. **23**:305–331. *pls. 3*. 1912.

[17] LINDNER, P., und CZISER, S., Der Alkohol, ein mehr oder weniger ausgezeichneter Nährstoff für verschiedene Pilze. Wochenschr. Brauerei **29**:1–6. 1912.

ability to assimilate alcohol, although varying with different races, is almost universal among these organisms. The loss thus sustained in the process of fermentation they suggest should be taken into consideration in devising methods of operation.

Similarly, in a short note WILL and HEUSS[18] show that, as is well known for other fungi, various budding forms, including species of *Mycoderma*, *Torula*, *Willia*, and *Pichia*, consume ethyl acetate, apparently utilizing both the acid and the alcohol radicle in their metabolism.

The study of the production of toxic substances by fungi growing on food products destined for human consumption has recently attracted much attention, especially in Italy in connection with the investigation of pellagra. From this point of view ALSBERG and BLACK[19] have investigated substances elaborated by two species of molds; the one, *Penicillium puberulum* Bainier, isolated from spoiled maize in Nebraska, and the other, *P. stoloniferum* from similar material from Italy. From the culture medium (RAULIN'S solution) in which *P. puberulum* was grown, the authors isolated a substance to which the name penicillic acid, with the formula $C_8H_{10}O_4$, was given. The substance, which behaves like a monobasic acid, is fatal to animals when injected subcutaneously in doses of 0.2–0.3 grams per kilogram of body weight. It is formed more abundantly when the air supply of the fungus is limited than with full aeration. An acid medium also favors its production.

Penicillium stoloniferum elaborates a non-toxic substance to which the name mycophenolic acid is given. Its empirical formula is $C_{17}H_{20}O_6$. It behaves like a dibasic acid and resembles the lichen acids in many ways. With ferric chloride this substance gives the violet color of GOSIO'S phenol reaction, which in Italy is regarded as a reliable test for the detection of deterioration in maize, but which the authors were unable to obtain in its characteristic form from samples of spoiled American maize.

In conclusion, the authors point out the desirability of utilizing biochemical behavior as an aid in the separation of species of molds which are not easily distinguished by morphological characteristics.

Owing to the ability of some molds to complete their development with traces of certain universal elements so minute that they cannot be removed by chemical means, the study of the influence of such elements on spore-production presents difficulties which account for the variant results obtained by different and sometimes by the same investigators. Formerly SAUTON[20] ascribed to iron a special rôle in the spore-production of *Aspergillus niger*, but later he and

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[18] WILL, H., und HEUSS, R., Essigsäureäthylester als Kohlenstoffquelle für Hefe und andere Sprosspilze. Zeitschr. Gesamte Brauwesen. **35**: 128–129. 1912.

[19] ALSBERG, C. L., and BLACK, O. F., Contributions to the study of maize deterioration. U.S. Dept. Agric., Bur. Plant Ind. Bull. 270. pp. 48. *pl. 1.* 1913.

[20] Rev. BOT. GAZ. **55**:86. 1913.

JAVILLIER[21] negatived this conclusion and attributed the lack of spore-formation in the absence of iron to the deleterious effect of zinc in RAULIN'S solution, for they found that when both zinc and iron were absent spores were produced by the fungus. Meanwhile, BERTRAND[22] reported experiments which seemed to indicate that manganese played a special part in the spore-production of *Aspergillus niger.*

The question of the influence of various elements on the spore-production of molds has now been further investigated by SAUTON.[23] He finds that if *A. niger* is grown on RAULIN'S solution to which iron in the form of ferric ammonium citrate has been added, no spores are produced, thus strengthening his conclusion that iron plays no special part in the spore-production of that fungus. If, however, iron sulphate is added to the solution, spores are produced. The difference in behavior of the two salts may be ascribed to the absence of manganese in the one and its presence in the other. The author finds, however, that in a solution without zinc, spores are produced in the absence of any detectable traces of iron and manganese, and concludes, therefore, that if these elements are necessary for *A. niger*, the requisite quantities are limited to such minute traces that they cannot be detected chemically. He finds that in this respect *A. fumigatus* is a more favorable object of experimentation. If of the two elements in question manganese alone is present in the culture solution, this fungus produces spores after 15 days, while with iron also present spores are produced on the third day. If manganese is absent no spores are formed. It appears, therefore, that for this mold both iron and manganese are necessary for spore-production. The influence of some of the other elements of RAULIN'S solution on spore-production was also determined. In the absence of sulphur *A. niger* grows poorly but nevertheless produces spores. *A. fumigatus*, however, does not produce spores in the absence of that element. No spores are produced by either mold in the absence of potassium, but the addition or withdrawal of caesium and rubidium are without influence. In the absence of phosphorus no spores are formed, but it does not seem to be possible to exclude magnesium to such an extent as to inhibit spore-formation.

It is likely that this work would lead to more definite results if it were separated from the problem of the toxicity of zinc, which although placed by RAULIN among the elements of his culture solution is not a substance necessary in the metabolism of plants.

BERTRAND and JAVILLIER[24] have republished their experiments on the action

[21] Rev. BOT. GAZ. **55**:88. 1913. [22] Rev. BOT. GAZ. **55**:89. 1913.

[23] SAUTON, B., Sur la sporulation de l'*Aspergillus niger* et de l'*Aspergillus fumigatus*. Ann. Inst. Pasteur **27**:328–335. 1913.

[24] BERTRAND, DR., et JAVILLIER, M., Action combiné du manganèse et du zinc sur le développment et la composition minérale de l'*Aspergillus niger*. Ann. Inst. Pasteur **26**:515–521. 1912.

of zinc and manganese, the first publication of which has been reviewed in this journal.[25]

From recent work of RITTER[26] and of HAGEM,[27] as well as from scattered observations in the older literature, it appears that the power of using nitrogen in the form of nitrite is widespread among filamentous fungi. A further contribution to this subject is made by KOSSOWICZ,[28] who finds that *Botrytis Bassiana*, *Penicillium glaucum*, *P. brevicaule*, *Mucor Boidin*, *Cladosporum herbarum*, *Phytophthora infestans*, *Aspergillus glaucus*, *A. niger*, *Isaria farinosa*, and a species of *Fusisporium* grow readily on synthetic culture solutions containing potassium as the sole source of nitrogen; and cane sugar, dextrose, or mannite as carbon compounds. The formation of ammonia could be definitely shown to occur only in mannite cultures of *Phytophthora infestans* and in those of *Fusisporium*. In cultures containing sugars the ammonia reaction of Nessler's reagent is not reliable on account of the similar reaction given by dextrose. It is erroneous, however, to conclude from the absence of the ammonia test that nitrites are not reduced to ammonia before being assimilated. The absence of ammonia merely shows that it is not produced in excess of the quantity used. In the absence of quantitative data showing the yields produced, the effect of nitrogenous substances in the tap water which the author used in his experiments cannot be easily estimated.

KOSSOWICZ and GRÖLLER[29] have investigated the value of sulphocyanates as sources of nitrogen, carbon, and sulphur for fungi. The same species of molds mentioned in the paper reviewed above were used in the experiments. It was found that in the absence of other nitrogenous compounds (except such as were introduced by means of the tap water and as impurities in the other compounds used) the fungi made a feeble growth which soon ceased in nutrient solutions containing ammonium, potassium, sodium, or iron salts of sulphocyanic acid. Traces of hydrogen sulphide were detected only in cultures of *Mucor Boidin* and occasionally in those of *Aspergillus niger* and *A. glaucus*. The conclusion that the fungi used in these experiments can obtain nitrogen from sulphocyanates would seem to need further support in view of the fact that in all cases there was a cessation of growth after a few days. The fungi made no growth when sulphocyanates were the sole source of carbon or of both carbon and nitrogen. A feeble growth appeared when the substance was the sole source of sulphur. Sulphocyanates seem to be only slightly toxic, although they cause a distinct depression of growth, yet even in a 10 per cent

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[25] BOT. GAZ. **55**:89. 1913.

[26] Rev. BOT. GAZ. **55**:91. 1913.

[27] Rev. BOT. GAZ. **55**:463. 1913.

[28] KOSSOWICZ, A., Nitritassimilation durch Schimmelpilze. Zeitschr. Gärungsphysiol. **2**:55–58. 1912.

[29] KOSSOWICZ, A., und GRÖLLER, L. VON, Rhodanverbindungen (Schwefelcyanverbindungen) als Kohlenstoff, Stickstoff, und Schwefelquelle für Schimmelpilze, Sprosspilze (Hefen), und Bakterien. Zeitschr. Gärungsphysiol. **2**:59–65. 1913.

solution growth is not entirely inhibited. The non-toxicity of sulphocyanates has also been observed by FERNBACH and in extremely dilute solutions by SAUTON.[30]

In a short note KOSSOWICZ and LOEW[31] report the availability of sodium thiosulphate as a nutrient for a number of yeasts and fungi. Hydrogen sulphide, free sulphur, and sulphuric acid are among the products resulting from the action of different organisms on the compound.—H. HASSELBRING.

The leaf-bud of Cordaites.—LIGNIER[32] has made an intimate study of the developing leaves of *Cordaites* from a portion of a silicified bud from the Stephanian of Grand' Croix (Loire). His piece of material was about 3 cm. long and in the matrix immediately around the bud proper and concentric with it had adult leaves identical in structure with *C. lingulatus* of RENAULT. He thinks it reasonable to suppose that these were borne on the same branch which bore the bud itself, especially since he found these leaves identical in structure with the outermost ones of the bud, with the exception of such differences as might be due to age. His conclusion that the bud is that of *C. lingulatus* seems beyond reasonable doubt.

In the young leaves the primordial strands are very small, the bast appearing to develop first as in living forms. In the older leaves the bast is almost always completely destroyed, so that practically nothing was seen of the secondary bast. The protoxylem and centripetal metaxylem develop early, with elements of typical form, ring, spiral, scalariform, and reticulate. The centrifugal wood comes later, appearing first in the region of the protoxylem. About the same time appear certain cells which LIGNIER designates "cellules diaphragmatiques," situated between the bundle sheath and either the body of the centripetal or the sides of the arc of centrifugal xylem. The region occupied by it may be quite extensive. LIGNIER has not compared the bundle with that of cycads, but similar cells do occur in the same region in the cycad bundle, especially lateral to the base of the centripetal xylem.

The sheath consists of several layers of large cells which differentiate early. The cells begin to thicken their walls when the xylem consists of only one or two tracheids. They are most abundant ordinarily at the sides of the bundle, and show certain resemblances to the xylem tissue, to which LIGNIER refers. Most, if not all, of their transverse walls are covered with "punctuations aréolées" and "serées," which are larger, however, and more irregular than those of the tracheary elements. Those on the longitudinal walls are even

[30] Rev. BOT. GAZ. **55**:86. 1913.

[31] KOSSOWICZ, A., und LOEW, W., Vorläufige Mitteilung über das Verhalten von Hefen und Schimmelpilzen zu Natriumthiosulfat. Zeitschr. Gärungsphysiol. **2**:78. 1913.

[32] LIGNIER, O., Différenciation des tissus dans le bourgeon végétatif du *Cordaites lingulatus* B. Ren. Ann. Sci. Nat. Bot. IX. **17**:233–254. 1913.